INDOOR AIR QUALITY ASSESSMENT

East Brookfield Municipal Building
Depot Square
East Brookfield, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Ruth McNeaNea, Director of the East Brookfield Public Health Department, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the East Brookfield Municipal Building (EBMB), Depot Square, East Brookfield, Massachusetts. Complaints of upper respiratory symptoms, headaches and other air quality-related symptoms prompted the request. Of particular concern was the presence of standing water and the potential for microbial growth in the basement.

On February 28, 2003 a visit was made to this building by Cory Holmes, Environmental Analyst of BEHA's Emergency Response/Indoor Air Quality (ER/IAQ), Program to conduct an indoor air quality assessment. Mr. Holmes was accompanied by Ms. McNeaNea and for portions of the assessment by Chief William Cournoyer of the East Brookfield Police Department (EBPD).

The EBMB is a three-story brick building, originally constructed as a factory. The building was reported to have a number of various uses over the years and was converted to office space for the town in the early 1970s'. The EBMB is built into the side of a hill, with the basement and portions of the first floor below grade. The third floor contains an attic that is used for storage and as an activity room for the local boy scout troop. The second floor is made up of the town library and an office for the historical society. The first floor contains the EBPD and office space for town business (Assessors, Town Clerk, etc.). The basement contains a number of empty rooms that formerly served as the EBPD, the boiler room and open areas that are used for storage.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Visual inspection for standing water, water damaged building materials and microbial growth was conducted. Water content in ceiling plaster and gypsum wallboard (GW) was measured with a Delmhorst, BD-2000 Model, Moisture Detector.

Results

The building has a part-time employee population of approximately 10 individuals and an estimated 5-10 members of the public who visit the building on a daily basis. Tests were taken under normal operating conditions. Test results appear in Tables 1-2. Air sampling results are listed in the tables by location that the air sample was taken.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were above 800 parts per million of air (ppm) in one of eleven areas surveyed throughout the building, indicating adequate air exchange in most areas. However it is important to note that most areas were unoccupied or sparsely populated during the assessment, which can greatly reduce carbon dioxide levels. It would be expected that carbon dioxide levels would rise during the heating season, with windows and exterior doors shut.

The building is not equipped with a modern mechanical ventilation system but relies on openable windows for air circulation. In a number of cases, openable windows in offices have been eliminated with the permanent installation of window-mounted air conditioners. Without a means for air exchange via windows or a mechanical supply and exhaust system, normally occurring indoor environmental pollutants (e.g. ozone from photocopiers, odors from cleaning products) can build up and lead to indoor air quality/comfort complaints.

All of the air conditioners examined were equipped with a "fan only" or "exhaust open" setting (see Picture 1). In this mode of operation air conditioning units can provide air circulation by delivering outside air into space without cooling (i.e. air provided by unit equals that of outside temperature).

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health

Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings were measured in a range of 63^{o} F to 75^{o} F, which was below the BEHA recommended comfort range in some areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Temperature control complaints were raised by a number of occupants, primarily excessive heat. Since the building was built prior to 1900, it was not designed for the use of modern office equipment. The combination of a lack of mechanical ventilation, waste heat producing equipment and single-paned window systems can make temperature control difficult.

Relative humidity measurements ranged from 19 to 27 percent, which were below the BEHA recommended comfort range in all areas surveyed. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. During the heating season, relative humidity levels would be expected to drop below the recommended comfort range. The sensation of dryness and irritation is common in a low relative humidity environment. For buildings in New England, periods of low relative humidity during the winter are often unavoidable.

Microbial/Moisture Concerns

As previously mentioned, a focus of occupant concern is the basement, which has reportedly been prone to flooding over the years. A number of moisture sources and water-damaged materials exist in the basement. BEHA staff observed one to two inches of standing water in several basement areas on the day of the assessment. Portions of the basement were divided by the construction of a wooden wall that was severely water damaged to the point where its base had disintegrated (see Picture 2). Porous materials that can support mold growth, such as books, cardboard, paper and ceiling tiles (stacked in piles on the basement floor) chronically exposed to moisture, have resulted in mold growth (see Pictures 2-4).

Basement flooding in the EBMB appears to be chronic, due to the age and extent of water damaged materials. Although the basement is equipped with a sump pump, it was not clear whether the pump was operable. In addition the pump reservoir was located up gradient to where the standing water was located (see Picture 5). No obvious interior moisture sources were noted. The most likely source of water in the basement is penetration through the foundation/walls. Several potential sources of water penetration into the basement as well as other areas of the building include:

- Missing/damaged mortar around bricks (see Picture 6), spaces between concrete stairs and the building were observed (see Pictures 7).

- Small trees/stumps, and other plants were growing in the tarmac/exterior wall junction (see Picture 8). The growth of roots/plants against the foundation/exterior walls of the building can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the foundation below ground level.
- No gutter/downspout system exists along the roof to direct rainwater away from the base of the exterior walls. Sections of the exterior walls were saturated with moisture. North-facing corners and walls of this building are particularly vulnerable to moisture for extended periods of time, since the brick is not dried out by exposure to direct sunlight. Excessive exposure of exterior brickwork to water can result in structural damage. Over time, these conditions can undermine the integrity of the building envelope and provide a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001). This may also allow for water to gather beneath the slab.
- In some areas flashing along the roof was detached from the building (see Picture 9), which can allow wind driven rain to penetrate the building envelope causing water damage to building materials.
- In some areas siding has become detached or completely removed from the exterior of the building (see Picture 10).
- Spaces were noted around exterior doors. Light could be seen penetrating through this space (see Picture 11) and drafts were noted. The floor around the

rear hallway door is carpeted. Depending on wind and weather conditions, rainwater can penetrate through this space and wet carpeting.

Each of these conditions compromises the integrity of the building envelope and can provide a means for water penetration into the building. Repeated water damage to porous building materials (e.g., wallboard, ceiling tiles, carpeting) can result in microbial growth. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous building materials be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed.

Several potential means for transportation of basement odors and particulates to occupied areas of the building also exist. The most obvious pathway is through the basement door in the main hallway. Airflow in buildings tends to rise from lower to upper floors (called the stack effect). Stairwells are prone to this condition. As airflow is created, airborne particulate matter and odors can migrate to occupied areas of the building. This door should be shut to minimize airflow into the main hallway. Other potential pathways for particulate/odor migration is through utility holes, floor cracks and other penetrations.

A number of areas in the attic and second floor showed signs of efflorescence (see Pictures 12 & 13). Efflorescence is a characteristic sign of water damage to building materials, but it is not mold growth. As moisture penetrates and works its way through building materials, water-soluble compounds dissolve, creating a solution. As this solution moves to the surface, the water evaporates, leaving behind white, powdery mineral deposits.

Other Concerns

Signs of insect infestation were also observed. A number of insect bodies were noted on windowsills in the library (see Picture 14). Insect parts can dry and become aerosolized and may serve as a source of allergenic material for sensitive individuals. The most likely route for insect penetration into the building is through breaches in the building envelope (holes, cracks, etc). The reduction/elimination of pathways of egress into the building should be the first step taken to eliminate this infestation.

As discussed, a number of areas had window-mounted air conditioning units. BEHA staff inspected filters in several of these units and found them coated with dirt/dust (see Pictures 15). Without cleaning/changing filters, the activation of these units can re-aerosolize dirt, dust and particulate, which can be irritating to certain individuals.

Also of note was the amount of materials stored inside offices. Items were seen piled on windowsills, tabletops, counters, bookcases and desks throughout the building. In addition some offices are configured in a manner that makes regular cleaning/vacuuming difficult. The large amount of items stored provides a means for dusts, dirt and other potential respiratory irritants to accumulate. Many of the items (e.g. papers, folders, boxes, etc.) make cleaning around these areas difficult for custodial staff. Dust can be irritating to the eyes, nose and respiratory tract. These items should be relocated and/or cleaned periodically to avoid excessive dust build up.

Finally, a number of wasps' nests were observed along the perimeter of the building (see Picture 16). Under current Massachusetts law that, effective November 1, 2001, the principles of integrated pest management (IPM) must be used to remove pests in state buildings and grounds (Mass Act, 2000).

Conclusions/Recommendations

Occupant symptoms and complaints at the EBMB appear consistent with what might be expected with conditions found in the building at the time of the assessment. These conditions present problems that will require a series of remedial steps. In view of the findings at the time of the visit, the following recommendations are made:

Materials Located within the Basement

Stored materials and building materials in the basement appear to have mold contamination. In order to avoid potential mold and related spore movement during remediation of the basement area, the following recommendations should be implemented in order to reduce contaminant migration into occupied areas and to better understand the potential for mold to impact indoor air quality.

1. Remove any mold-contaminated materials (e.g. stored items) in the basement. Remove and replace (if necessary) any water damaged/mold colonized building materials. This measure will remove actively growing mold colonies that may be present. Remove mold contaminated materials in a manner consistent with recommendations found in "Mold Remediation in Schools and Commercial Buildings" published by the US Environmental Protection Agency, Office of Air

and Radiation, Indoor Environments Division, Washington, DC. EPA 402-K-01-001. March 2001. Copies of this document can be downloaded from the US EPA website at: http://www.epa.gov/iaq/molds/mold_remediation.html

2. Establish communications between all parties involved with remediation efforts (including building occupants) to prevent potential IAQ problems.
3. Develop a notification system for building occupants immediately adjacent to (and above) the basement to report remediation/construction/ renovation related odors and/or dusts problems to the building administrator. Have these concerns relayed to the contractor in a manner that allows for a timely remediation of the problem.
4. When possible, schedule projects which produce large amounts of dusts, odors
5. Use local exhaust ventilation and isolation techniques to control remediation pollutants. Precautions should be taken to avoid the re-entrainment of these materials into the building.
6. Seal utility holes, spaces in roof decking and temporary walls to eliminate pollutant paths of migration. Seal holes created by missing tiles in the ceiling temporarily to prevent renovation pollutant migration.
7. Seal basement/hallway doors with polyethylene plastic and duct tape. Consider creating an air lock of a second door inside the remediation spaces to reduce migration.
8. If possible, relocate susceptible persons and those with pre-existing medical conditions (e.g. asthma) away from the general areas of remediation until completion.

9. Implement prudent housekeeping and work site practices to minimize exposure to spores. This may include constructing barriers, sealing off areas, and temporarily relocating furniture and supplies. To control for dusts, a high efficiency particulate air filter (HEPA) equipped vacuum cleaner is recommended. Non-porous materials (e.g., linoleum, cement, etc.) should be disinfected with an appropriate antimicrobial agent. Non-porous surfaces should also be cleaned with soap and water after disinfection.

General Air Quality Recommendations

1. Consult with an architect and or general contractor regarding the integrity of the building envelope, primarily concerning water penetration through walls and the foundation.
2. Repair and/or replace thermostats as necessary to maintain control of comfort.
3. Consult with an HVAC engineering firm to examine the feasibility of providing mechanical supply and exhaust ventilation in the building.
4. Examine the feasibility of having a downspout/gutter system installed to direct water away from the alleyway.
5. Remove plants from the wall/tarmac junction around the perimeter of the building. Seal the wall/tarmac junction with an appropriate sealer.
6. Ensure all roof leaks are repaired. Once the roof is repaired, repair water damaged plaster and examine the feasibility of repointing brickwork.

7. This building was designed to use windows to provide fresh air. In order to temper room temperature and provide fresh air, the opening of windows is recommended.
8. Render the access door to the basement airtight with weather-stripping.
9. Seal holes in the floors, walls and ceilings for pipes and cables to prevent infiltration of basement pollutants.
10. Relocate or consider reducing the amount of materials stored to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
11. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, continue to use the HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
12. It is highly recommended that the principles of integrated pest management (IPM) be used to rid this building of pests. A copy of the IPM recommendations can be downloaded from the Internet at http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf.
13. Change/clean filters for air conditioning units as per the manufacturer's instructions or more frequently if needed.

14. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

References

ACGIH. 1998. American Conference of Governmental Industrial Hygienists. Industrial Ventilation A manual of Recommended Practice. 23rd Edition. 1998.

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1

Lstiburek, J. & Brennan, T. 2001. Read This Before You Design, Build or Renovate. Building Science Corporation, Westford, MA. U.S. Department of Housing and Urban Development, Region I, Boston, MA

Mass. Act. 2000. An Act Protecting Children and families from Harmful Pesticides. 2000 Mass Acts c. 85 sec. 6E.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R. 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

Picture 1

Control Panel for Window-Mounted AC, Note "Fan Only" Setting

Picture 2

Severely Water Damaged, Mold Colonized Wooden Wall in Basement

Picture 3

Various Porous Water-Damaged/Mold Colonized Materials in Basement

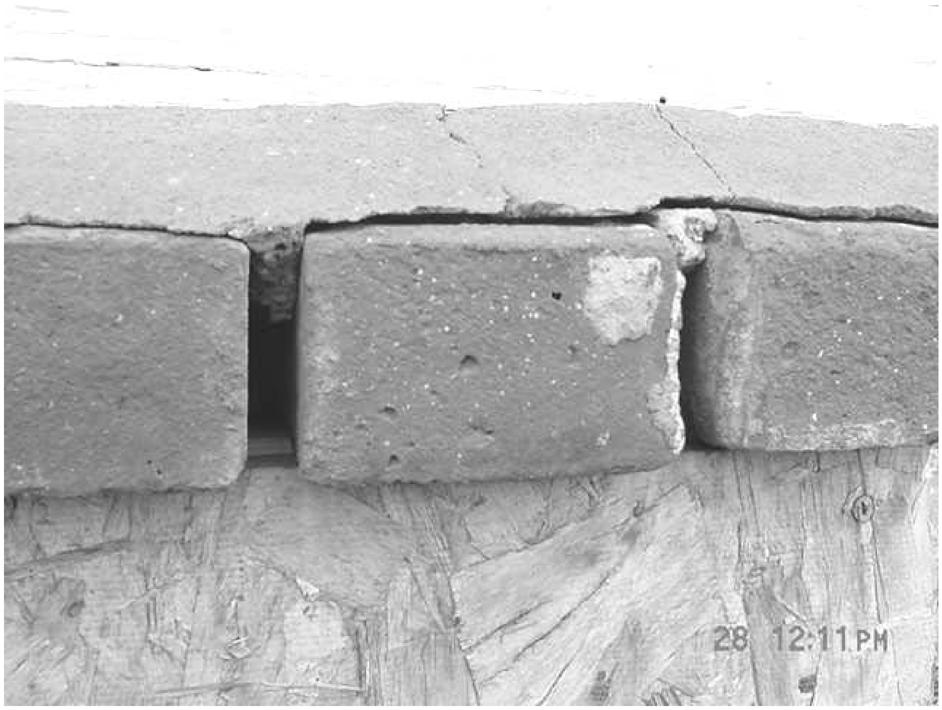
Picture 4

Water-Damaged/Mold Colonized Ceiling Tiles

Picture 5

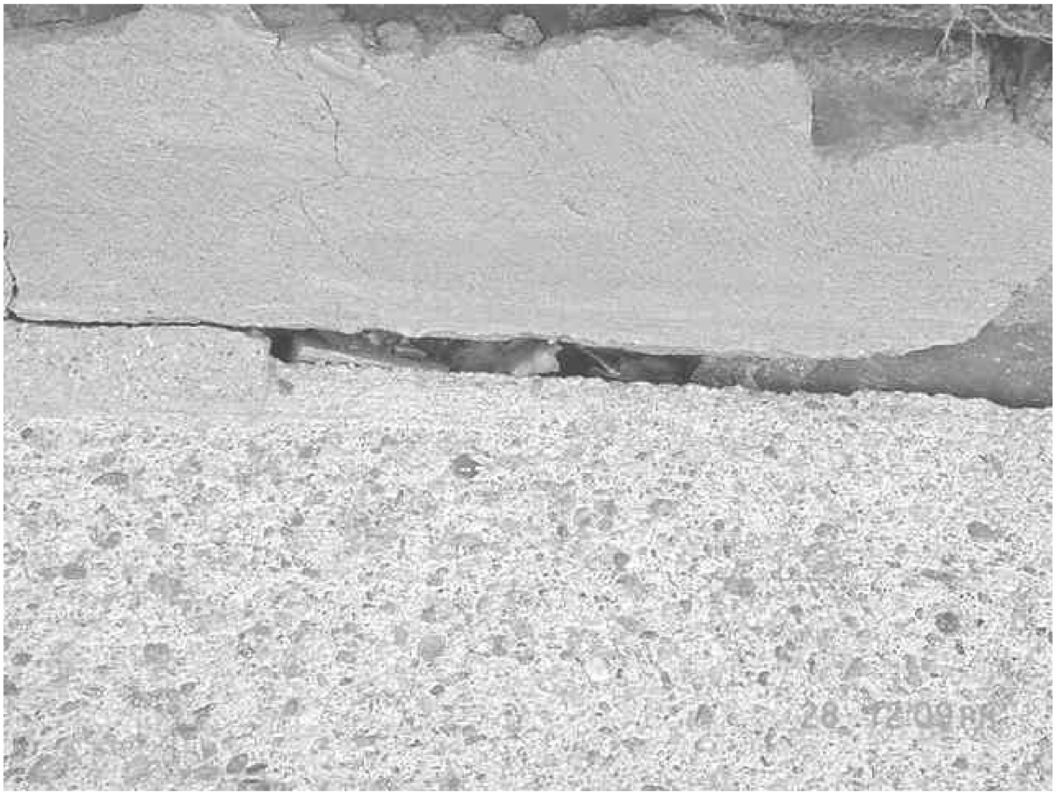
Sump Pump in Basement

Picture 6



Missing/Damaged Mortar around Bricks

Picture 7

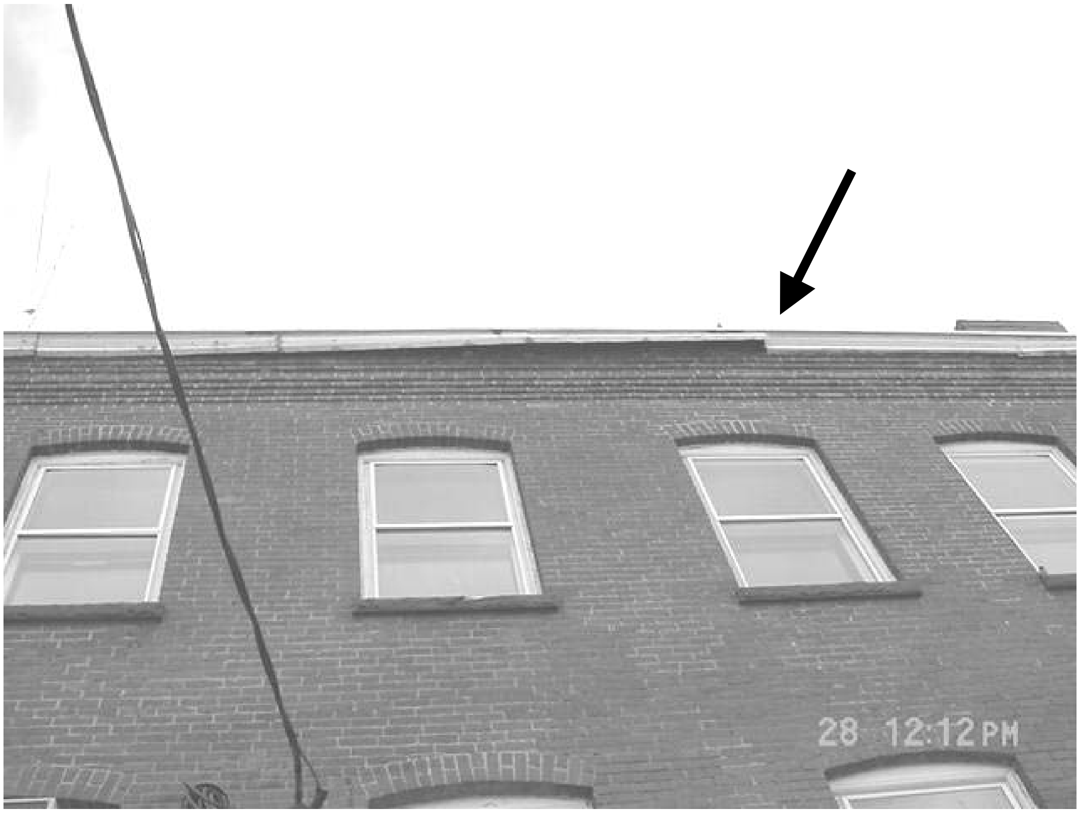


Spaces in Front Concrete Stairwell

Picture 8

Small Trees/Plants Growing against the Building

Picture 9



Roof Flashing Detached from the Building

Picture 10

Missing/Damaged Siding on Exterior Wall

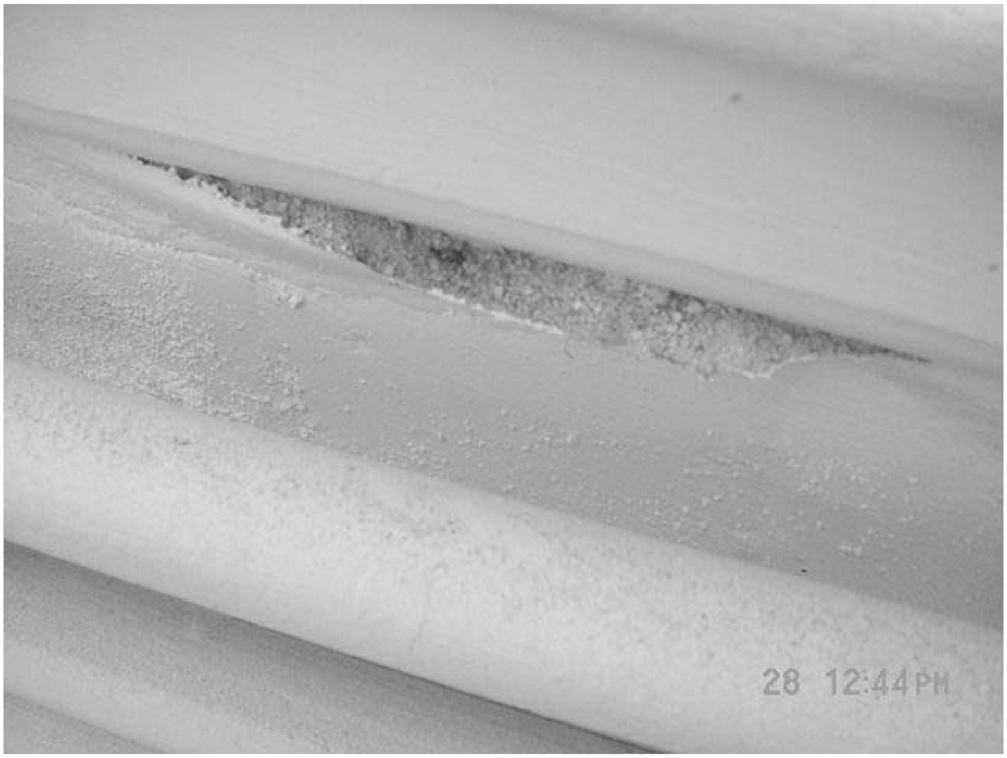
Picture 11

Spaces beneath Exterior Door Rear Hallway Carpeted Area

Picture 12

Efflorescence on Attic Brickwork Indicating Water Penetration

Picture 13

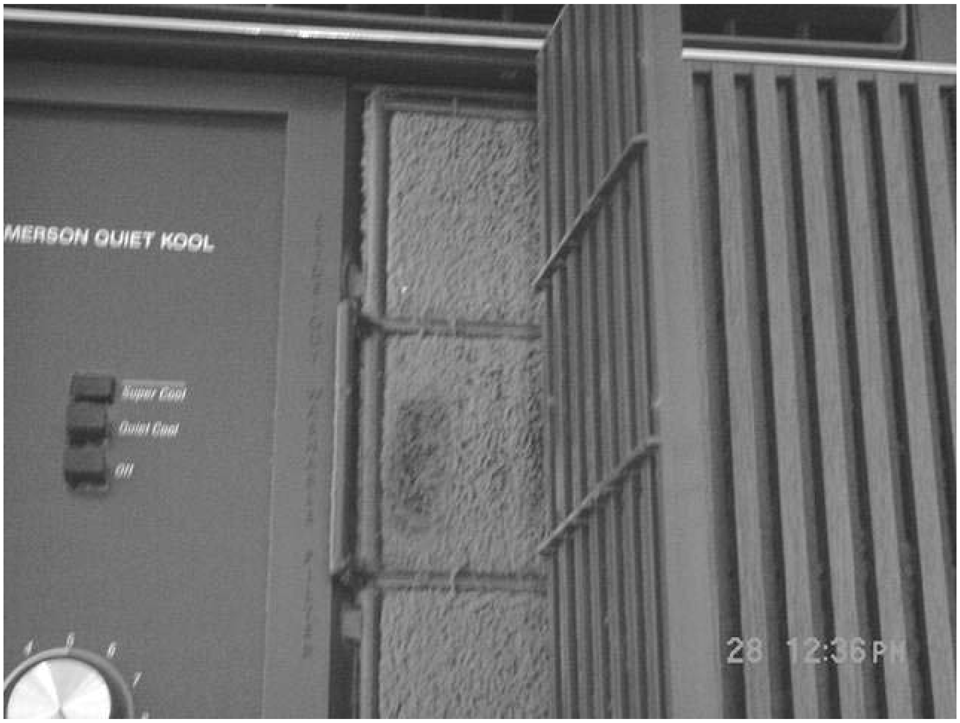


Efflorescence Trapped behind Paint on Interior Brickwork in the Library

Picture 14

Insect Bodies on Library Windowsill

Picture 15



AC Filter Occluded With Dust and Debris

Picture 16

Wasp's Nest along Exterior of the Building

TABLE 1

Indoor Air Test Results – East Brookfield – Municipal Building, Massachusetts– February 28, 2003

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	369	46	21					Cold and cloudy Light breeze
Attic Boy Scout Area	582	64	22	0	Y	N	N	Efflorescence – WD ceiling plaster
Stairwell								Dirt and dust Cobwebs
Historical Office	499	63	30	0	Y	N	N	WD ceiling plaster Carpet and dusty, cobwebs
Library	605	71	23	0	Y	N	N	Filters saturated, photocopier Carpeted and window AC Card board boxes against heat pipes Ladybug bodies
Town Clerk	857	74	19	3	Y	N	N	Window AC, shag rug Office equipment
Town Collector	632	75	21	0	N	N	N	
Assessors	693	75	21	2	N	N	N	Window AC
Selectman	549	75	22	1	Y	N	N	Photocopier
Treasurer	562	74	22	0	Y	N	N	AC

*** ppm = parts per million parts of air**
WD = water damage

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – East Brookfield – Municipal Building, Massachusetts– February 28, 2003

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Board of Health	557	73	21	1	Y	N	N	
Custodial Closet					N	N	N	No local exhaust
Rear Hallway								Space under door Carpeted hallway
Basement								Standing water, water damage Mold, colonized porous materials, Ceiling tiles on floor, boxes/papers etc.
Police Booking Area	612	70	25	2	Y	N	N	
Chief Office	534	72	23	1	Y	N	N	Report that window not operable

*** ppm = parts per million parts of air**
WD = water damage

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%